

1928 A.M.DIRAC PROPOSES A RELATIVISTIC QUANTUM THEORY



Paul Adrien Maurice Dirac
(1902-1984)

English mathematician and theoretical physicist. His first major contribution (1925/26) was a general and logically simple form of quantum mechanics. He shared the 1933 Nobel Prize for Physics with Erwin Schrödinger.

Overview

In particle physics, the Dirac equation is a relativistic wave equation formulated by British physicist Paul Dirac in 1928. It describes fields corresponding to elementary spin- $\frac{1}{2}$ particles (such as the electron) as a vector of four complex numbers (a bispinor), in contrast to the Schrödinger equation which described a field of only one complex value.

Mathematical formulation

$$\left(\beta mc^2 + \sum_{k=1}^3 \alpha_k p_k c \right) \psi(\mathbf{x}, t) = i\hbar \frac{\partial \psi(\mathbf{x}, t)}{\partial t}$$

where

$\psi = \psi(\mathbf{x}, t)$ is the wave function for the electron,

\mathbf{x} and t are the space and time coordinates,

m is the rest mass of the electron,

p is the momentum, understood to be the momentum operator in the Schrödinger theory,

c is the speed of light, and $\hbar = h/2\pi$ is the reduced Planck constant.

Impact

Building on Wolfgang Pauli's work on non-relativistic spin systems, Dirac proposed the "Dirac equation" in 1928 as a relativistic equation of motion for the wave function of the electron. This work also led him to his prediction of the existence of the positron (the antiparticle of the electron, identical to it in every aspect but its charge, the existence of which was later observed and confirmed by Carl Anderson in 1932) and matter-antimatter annihilation, as well as contributing to the explanation of the origin of quantum spin as a relativistic phenomenon.